On the Magnitude of Exporter Productivity Premia

Ingo Geishecker* Philipp J.H. Schröder† Allan Sørensen‡

April 2012

Abstract

Why is it that exporter productivity premia (EP) differ so widely in magnitude? We take this question to the theory and to the data. First, we compute the theoretical equivalent of empirical measures of sectoral EP in a standard heterogeneous firms trade model. This gives novel predictions: a larger variance in the productivity distribution and larger trade costs (both fixed and variable) in a sector increases the sectors EP, while the effect of the degree of product differentiation is ambiguous. Second, based on 15 years of data for the universe of Danish manufacturing firms, we confirm the role of trade costs for sectoral EP. Most importantly, we establish that the variance in the underlying productivity distribution is decisive for the size of a sectors EP. These findings imply substantial room for refinements when conducting empirical research into exporter performance.

JEL: F12, F15, O33, L11, L16
Keywords: Intra-industry trade, exporter productivity, firm level data, monopolistic competition, heterogeneous firms.

*Georg-August-University Göttingen, Faculty of Economic Sciences, Germany. Tel.:+49 (0)551 39 7337, E-mail: Ingo.Geishecker@wiwi.uni-goettingen.de.

†Aarhus University, Business and Social Sciences, Department of Economics and Business, Denmark. Tel.: +45 871 64971 , E-mail: psc@asb.dk.

‡Aarhus University, Business and Social Sciences, Department of Economics and Business, Denmark. Tel.: +45 871 64989 , E-mail: allans@asb.dk.

Acknowledgements: Ingo Geishecker and Philipp Schröder acknowledge financial support from the Tuborg Foundation.

1 Introduction

The stylized fact of a positive exporter productivity premia (EP) – and the elegant new theories that came along with it (e.g. Melitz, 2003) – have intrigued empirical and theoretical researchers in international economics; see Greenaway and Kneller (2007), Wagner (2007, 2012), Redding (2011) and Bernard et al. (2012) for surveys. Despite the impressive volume of analyses, a central question remains open. Why is it that exporter productivity premia vary so widely in size across countries and across industries? Empirically, productivity premia range, for example in Europe, from 7 (0) percent in Sweden to 58 (10) percent in Belgium for identical pooled (fixed effects) estimation specifications on comparable data (ISGEP, 2008, table 4). On the sectoral level – the focus of the present paper – the issue is even more pronounced. We establish for Denmark TFP-based fixed effect EP estimates across 99 sectors that span from -10% to +496%. On first sight theory is silent on such size differences and empirical research has produced such results largely uncommented.

To be fair, short of classifying EP differences in magnitude simply as idiosyncratic characteristics of sectors or differences in econometric estimation strategies, a large number of renown papers that report sectoral EP differences have addressed the issue by executing additional empirical investigation, for example by splitting samples according to firm size or age and by providing plausible rationalizations; see e.g. Aw and Hwang (1995), Aw et al. (2000), Farinas and Martin-Marcos (2007), Head and Ries (2003), or Merino (2004); still, what is missing on the issue of EP magnitude is an exploration of the explicit link between the existing heterogeneous firms trade theory and the empirical patterns.[1] The current paper takes a step towards closing this gap.

First, we turn to theory. A simple thought experiment illustrates the task. Consider a standard heterogenous firms trade model and add one extremely productive firm. At first sight, this should increase the EP. Yet, actual empirical EP measures compare the group of exporters to non-exporters. Via

[1] Similarly, ISGEP (2008) establishes and discusses intensively the identified size differences between country EPs – in contrast much of the remaining literature are single country studies (see the surveys of Greenaway and Kneller, 2007; Wagner, 2007, 2012; and Bernard et al., 2012) that report EPs without systematic comparison to other findings. In particular, the implementation of different estimation strategies makes comparisons difficult. Moreover, ISGEP (2008) examines the export intensity driven premia and provides a discussion on how items such as fixed export costs or country size might contribute to explain EP size differences since they will matter for export intensity for example through the extensive margin. Still, an analysis based on predictions from existing theory is not provided.

general equilibrium effects the addition of a highly productive firm toughens the exit and exporter cut-off and thus changes the composition of firms in both groups. Hence, it becomes a non-trivial task to compute the overall effect on the EP. Accordingly, we start out by computing the theoretical equivalent of the empirically measure of sectoral EP in a symmetric two-country multi-sector version of a Melitz (2003) model. In contrast, previous theoretical work has simply considered the rankings of firms according to productivity. Such ranking implies that firms above the export threshold export and firms below will not export, whereby the export threshold is the level of productivity that implies zero profits from exporting. While a positive sign for the EP follows directly from this exercise, inference on the drivers of EP magnitude is not easily provided, since selection, the movement of cut-offs, and reallocation might all affect the actual EP. We resolve these issues and present predictions from theory addressing the interaction of exogenous (and empirically measurable) variables with the sectoral EP. Theory predicts that a larger degree of heterogeneity in the productivity distribution of a sector and higher trade costs (both fixed and variable) imply a larger sectoral EP. Furthermore, from the model we show that smaller home fixed costs correlate positively with the sectors EP, while the effects of the degree of product differentiation are ambiguous.

Previous theoretical work by Schröder and Sørensen (2012) has investigated exporter productivity, both in a Melitz (2003) setting as well as in a Bernard et al. (2003) model, yet focusing on the possibility that observable exporter productivity of an individual firm may fall in response to a firm switching its status from pure domestic to exporter (i.e. thus going counter to the productivity ranking established in marginal productivity). In their work, Schröder and Sørensen (2012) already note that the underlying distribution of marginal productivities must matter for the sign of the EP. Yet their main focus is on individual firms' observable productivity and on constructing – i.e. proof by contradiction – single stylized examples of aggregated negative EPs. In contrast, the present paper computes a comprehensive theoretical equivalent of sectoral EP and examines how this measure responds to changes in all the different parameters of the model.

Second, we take the predictions of the theory to the data. Based on 15 years of firm-level data for the universe of Danish firms, including destination and product codes, we are able to implement estimations of sectoral EPs for 3-digit level industries. We confirm the role and effect of trade costs: sectors with higher fixed export costs feature larger EPs. Most importantly, we establish that the variance in the underlying productivity distribution is decisive for the size of EP realizations: sectors with a larger degree of heterogeneity display larger magnitudes of EP. Furthermore, the degree of product differentiation – just as in the theory – gives ambiguous results.

These findings imply substantial room for refinements when conducting empirical research into exporter performance. For example, when assessing EP by pooling firms across different industries, as commonly done in the literature, parametric and non-parametric estimates will be affected by the underlying and potentially changing structure of industry characteristics. Accordingly, comparisons of EPs across time are potentially problematic if industry characteristics such as the degree of productivity heterogeneity are ignored. Furthermore, even though the present paper focuses on sectoral EPs, the question of cross-country differences remains unanswered. Our theoretical and empirical results provide inspiration for future research based on cross-country data sets. Our findings show that one strategy for explaining cross-country EP differences might be to utilize the cross-country differences in industry structure in general and the degree of firm heterogeneity in particular, which could easily be assessed from the available export or industry data.

The remainder of the paper is structured as follows. Section 2 introduces and calculates the EP in a two-country symmetric multi-sector Melitz (2003) model augmented with Pareto distributed productivities. Section 3 presents our data and empirical setup. Section 4 presents our empirical results and compares them to the theory. Section 5 concludes.

2 Exporter Productivity Premia in Theory

We derive exporter productivity premia in a symmetric two-country version of Melitz (2003). We make only two modifications. First, in order to reflect cross-sectoral variation in EP we rewrite the model to include J heterogeneous sectors. This extension is only a matter of exposition. Second, to ensure tractability and transparency and to obtain clear-cut predictions on how the EP depends on industry-specific characteristics we adopt the conventional assumption of productivities being Pareto distributed.[2]

[2]For applications of the Pareto distribution within heterogeneous firm trade models, see e.g. Helpman et al. (2004) and Chaney (2008). Moreover, the Pareto approximates the distribution of productivity of firms found in empirical work (see e.g. Simon and Bonini, 1958; and more recently Axtell, 2001; and Luttmer, 2007), and certainly resembles the empirical patterns we find for Danish firms in Section 3.

2.1 Households

A representative household supplies L units of labor inelastically to the labor market and derives utility from consumption of different varieties from the J sectors. The utility function of the household reads

$$U = u\left(C_1, C_2, .., C_J\right),$$

where C_j denotes the consumption of the sector j specific composite consumption bundle.[3] The composite consumption bundles are of the Dixit-Stiglitz (1977) CES type

$$C_j = \left(\int_{\omega \in \Omega_j} \left(c_j\left(\omega\right)\right)^{\frac{\sigma_j - 1}{\sigma_j}}\right)^{\frac{\sigma_j}{\sigma_j - 1}} \quad \text{for } j = 1, 2, .., J\ , \tag{1}$$

where $c_j\left(\omega\right)$ denotes consumption of variety ω of sector j, Ω_j is the endogenously determined set of varieties (both domestic and foreign) from sector j available to the household and σ_j is the elasticity of substitution between any two varieties within sector j. It follows that σ_j is inversely related to the degree of product differentiation within sector j. Demand for variety ω of sector j becomes

$$c_j\left(\omega\right) = C_j\left(\frac{p_j\left(\omega\right)}{P_j}\right)^{-\sigma_j} \quad \text{for } j = 1, 2, .., J \text{ and } \forall\ \omega \in \Omega_j\ , \tag{2}$$

where $p_j\left(\omega\right)$ is the price of variety ω of sector j and P_j is the price of buying one unit of the composite bundle C_j.[4]

2.2 Firms

All J sectors feature monopolistic competition. Accordingly, firms take the sector level variables C_j and P_j as given. Each firm only produces one unique variety ω within a single sector. Labor is the only input factor and remunerated at the economy wide wage rate w.[5] Entry into a sector, i.e. inventing a

[3] We assume that all first-order partial derivatives are positive, i.e. utility increases in all the sector-specific consumption bundles (defined by (1)).

[4] The price index reads

$$P_j = \left(\int_{\omega \in \Omega_j} \left(p_j\left(\omega\right)\right)^{1-\sigma_j}\right)^{\frac{1}{1-\sigma_j}} \quad \text{for } j = 1, 2, .., J\ .$$

[5] Labor can be reinterpreted as a composite input factor that is common for all firms.

new variety, is associated with sunk costs of $f_{e,j}$ units of labor. The creation of a new variety entails a variety-specific and fixed productivity, $\varphi_j(\omega)$. Realized productivity is stochastic due to the random nature of R&D processes. We assume that productivities are drawn from sector-specific known Pareto distributions with location parameters $\varphi_{0,j}$ and shape parameters γ_j.[6] The cumulative density functions thus read

$$G_j(\varphi_j(\omega)) = 1 - \left(\frac{\varphi_j(\omega)}{\varphi_{0,j}}\right)^{-\gamma_j} \quad \text{for } j = 1, 2, .., J\ . \tag{3}$$

Firms that decide to produce face fixed costs of production f_j such that the labor requirement of a firm with productivity $\varphi_j(\omega)$ that produces q units becomes $l_j(q|\varphi_j(\omega)) = \frac{q}{\varphi_j(\omega)} + f_j$. In addition, firms have the option to export. Exporting is subject to fixed export costs of $f_{j,x}$ units of labor and variable export costs of the iceberg type, i.e. firms must ship τ_j units for one unit to arrive.

Given the constant elasticity of demand, cf. (2), firms in each sector set prices as constant mark-ups on marginal costs implying that domestic (subscript d) and export market (subscript x) prices are given by

$$\begin{aligned} p_{j,d}(\varphi_j(\omega)) &= \frac{\sigma_j}{\sigma_j - 1}\frac{w}{\varphi_j(\omega)} \\ p_{j,x}(\varphi_j(\omega)) &= \frac{\sigma_j}{\sigma_j - 1}\frac{w\tau_j}{\varphi_j(\omega)}\ . \end{aligned}$$

Accordingly, reduced form profits in the domestic market and in the export market of a sector are given by

$$\begin{aligned} \pi_{j,d}(\varphi_j(\omega)) &= B_j(\varphi_j(\omega))^{\sigma_j - 1} - wf_j \\ \pi_{j,x}(\varphi_j(\omega)) &= B_j(\varphi_j(\omega))^{\sigma_j - 1}\tau_j^{1-\sigma_j} - wf_{j,x} \end{aligned}$$

where $B_j \equiv C_j(P_j)^{\sigma_j}\left(\frac{\sigma_j}{\sigma_j - 1}\right)^{-\sigma_j}\frac{1}{\sigma_j - 1}(w)^{1-\sigma_j}$ is a sector specific demand component. It follows that profits increase in productivity $\varphi_j(\omega)$ and only firms with sufficiently high productivity find it profitable to enter a given market. Consequently, firms self-select according to productivity into exiters ($\varphi_j(\omega) < \varphi^*_{j,d}(\omega)$), pure domestic non-exporters ($\varphi^*_{j,d}(\omega) \leq \varphi_j(\omega) < \varphi^*_{j,x}(\omega)$) and exporters ($\varphi_j(\omega) \geq \varphi^*_{j,x}(\omega)$) where the exit thresholds, $\varphi^*_{j,d}(\omega)$,

[6] We impose the parameter restriction $\gamma_j > 2$ in order to have finite variance of the productivity distribution.

and export thresholds of a sector ($\varphi_{j,x}^{*}(\omega)$) are defined by

$$\pi_{j,d}\left(\varphi_{j,d}^{*}(\omega)\right) = 0 \Leftrightarrow \varphi_{j,d}^{*}(\omega) = \left(\frac{wf_j}{B_j}\right)^{\frac{1}{\sigma_j-1}} \tag{4}$$

$$\pi_{j,x}\left(\varphi_{j,x}^{*}(\omega)\right) = 0 \Leftrightarrow \varphi_{j,x}^{*}(\omega) = \left(\frac{wf_{j,x}\tau_j^{\sigma_j-1}}{B_j}\right)^{\frac{1}{\sigma_j-1}} . \tag{5}$$

We impose the parameter restriction $f_{j,x}\tau_j^{\sigma_j-1} > f_j$ which ensures that firms – in line with empirical evidence – partition into exports and non-exporters.

2.3 Theoretical EP predictions

Within the above specification we are able to compute sectoral EPs. In particular, we derive the theoretical EP measure that corresponds to empirical measures, namely, comparing the difference in average productivity between the group of exporters and the group of non-exporters relative to the average productivity of the group of non-exporters. The assumption of CES consumption bundles ensures that the different sectors' structures and accordingly the sectoral EPs do only depend on the specific variables for the sector in question and not on the equilibrium values of all B_j for $j = 1, 2, .., J$. The EP in sector j reads:

$$PR_j \equiv \frac{E\left(\varphi_j(\omega) \middle| \varphi_j(\omega) \geq \varphi_{j,x}^{*}\right) - E\left(\varphi_j(\omega) \middle| \varphi_{j,d}^{*} \leq \varphi_j(\omega) < \varphi_{j,x}^{*}\right)}{E\left(\varphi_j(\omega) \middle| \varphi_{j,d}^{*} \leq \varphi_j(\omega) < \varphi_{j,x}^{*}\right)} . \tag{6}$$

By using the Pareto distribution given in (3), one can rewrite (6) as

$$PR_j = \frac{\left(\frac{\varphi_j^{*}}{\varphi_{x,j}^{*}}\right)^{-\gamma_j} - 1}{\left(\frac{\varphi_j^{*}}{\varphi_{x,j}^{*}}\right)^{-\gamma_j+1} - 1} - 1 . \tag{7}$$

We can now state:

Proposition 1. *The theoretical equivalent of the empirical measure of the exporter productivity premium, PR_j in sector j depends only on the sector variables $\gamma_j, f_{j,x}, \tau_j, f_j$ and σ_j and is given by*

$$PR_j = \frac{\left(\frac{f_{j,x}\tau_j^{\sigma_j-1}}{f_j}\right)^{\frac{\gamma_j}{\sigma_j-1}} - 1}{\left(\frac{f_{j,x}\tau_j^{\sigma_j-1}}{f_j}\right)^{\frac{\gamma_j-1}{\sigma_j-1}} - 1} - 1 . \tag{8}$$

Proof. The premium follows from evaluating (7) using the thresholds given by (4) and (5). □

Proposition 1 implies a series of results on how different sector variables affect the magnitude of a sector's EP.[7]

Corollary 1. *Sectors that are more heterogeneous in their productivity distribution (lower γ_j, implying a higher productivity dispersion) have larger exporter productivity premia.*

Corollary 2. *Sectors that have higher fixed costs of exporting ($f_{j,x}$) have larger exporter productivity premia.*

Corollary 3. *Sectors that have higher variable trade costs (τ_j) have larger exporter productivity premia.*

Corollary 4. *Sectors that have lower fixed costs of production (f_j) have larger exporter productivity premia.*

Corollary 5. *Sectors in which goods are more (less) differentiated, i.e. lower (higher) σ, have a larger exporter productivity premia iff the sectors' fixed costs of exporting, $f_{j,x}$, are below (above) the fixed costs of production f_j.*

Corollaries 1 to 5 provide clear and potentially testable predictions on the drivers of EP size differences. Obviously, the assumptions on the distribution of productivity are important for these results. To illustrate: consider the effect of fixed export costs on the premium (Corollary 2). As is well known from the Melitz (2003) model, higher fixed export costs reduce the domestic exit threshold and increase the export threshold. The lower exit threshold ceteris paribus reduces average productivity among non-exporters and thus increases the premium as more low-productive pure domestic firms appear in the sector. The higher export threshold has two opposing effects. On the one hand, it increases average productivity among exporters and thus the EP should increase. On the other hand, at the same time it increases average productivity among non-exporters as the least productive exporters shift status and become non-exporters. Thus in general no clear-cut results are to be expected and some structure on the productivity distribution is required to obtain predictions on the EP drivers. The Pareto distribution is particularly convenient in this respect, not just because we find strong empirical support for its applicability to our firm-level data (see Figure 1),

[7] The proofs of the Corollaries follow directly from the partial derivatives of the expression for the sector-specific productivity premium (8).

but also because its highly trackable properties imply that the EP becomes a function of only two independent arguments, namely the ratio of the export threshold to the exit threshold and the shape parameter of the Pareto.

Against this background it should be noted that the effect on the attractiveness of the export market relative to the domestic market underlies the results of Corollaries 2, 3, 4 and 5. To understand Corollary 1, note that the degree of heterogeneity increases (higher productivity dispersion) when the right tail of the distribution has more mass (lower γ_j). More mass in the tail in turn increases the density among highly productive firms – both exporters and non-exporters. However, the effect is less pronounced for non-exporters because their productivity distribution, unlike that of exporters, is right truncated.

Finally, our findings on the drivers of EP size differences – even though cast in a multi-sector interpretation – translate to cross-country EP size differences.

3 Data and Empirical Estimation Strategy

In line with the theoretical foundation outlined in Section 2, our empirical focus lies on sectoral EPs.[8] As always when taking theory to the data, it is important to acknowledge the wide range of forces that affect real countries and firms' trading patterns, but that have been conveniently ignored in the theoretical setup. For example, alternative drivers of trade, such as comparative advantage or effects stemming from country size asymmetries, are all absent in our theoretical EP results, but will matter in the data. Furthermore, time and timing – an illusive concept when studying steady state equilibria – will clearly be present in our firm-level data. Finally, as Eaton et al. (2012) have pointed out recently, the conventional modeling of firms as points on a continuum creates additional – potentially costly – discrepancies between theory and data.

Still, taking the workhorse model of heterogeneous firms trade and seeing what light it can shed on the substantial cross-sectoral EP size differences is a significant step forward and as such follows naturally from the previous literature. Wagner (2007, 2012) provides comprehensive surveys of the empirical literature and finds almost universal support for the view that the substantial positive EPs found in the literature are caused by the most productive firms self-selecting into export markets (for other recent studies see e.g., López,

[8]An alternative research design could examine cross-country EP variations, however, data collection and coding differ across countries, and even the comprehensive study of ISGEP (2008) arrives at only 14 comparable countries.

2009; Kneller and Pisu, 2010; Vinzenzo and Wagner, 2011). In the same spirit, Bernard et al. (2007, p. 111) argue that: "Results from virtually every study across industries and countries confirm that high productivity precedes entry into export markets". At the same time, empirical support for the hypothesis that firms become more productive as a consequence of exporting is much weaker (see Kneller and Pisu, 2010, for a recent survey). Of course both hypotheses, self-selection and learning through exports, are not mutually exclusive. Accordingly, we will evaluate whether our results are robust to potential reversed causality.

3.1 Data

Our data set consists of Danish firm-level data provided by Statistics Denmark for the period 1993-2008 and combines destination-specific export information with business account information. Starting from the universe of all Danish firms, we exclude non-manufacturing firms and firms with less than 5 employees. Furthermore, we do not include firms with a negative total revenue or a negative export revenue as well as firms with an export revenue greater than the total revenue, which we argue have been wrongly recorded. The resulting sample is composed of 41,320 firms, of which 9,930 exporters sell to a total of 168 countries. The central variables capital and labor are measured as firms' total fixed assets and as firms' number of full-time equivalent employees, respectively.[9]

Sectoral information is calculated at the 3-digit level, giving us 99 sectors with active exporters to compare and analyze sectoral EP differences across. Finally, the firm-destination data set is complemented with distance data and the various sectors' degrees of product differentiation are determined based on the Rauch (1999) classification.

Kernel density estimates of TFP (Figure 1) disclose that the underlying productivity distribution for Denmark resembles the Pareto distribution.

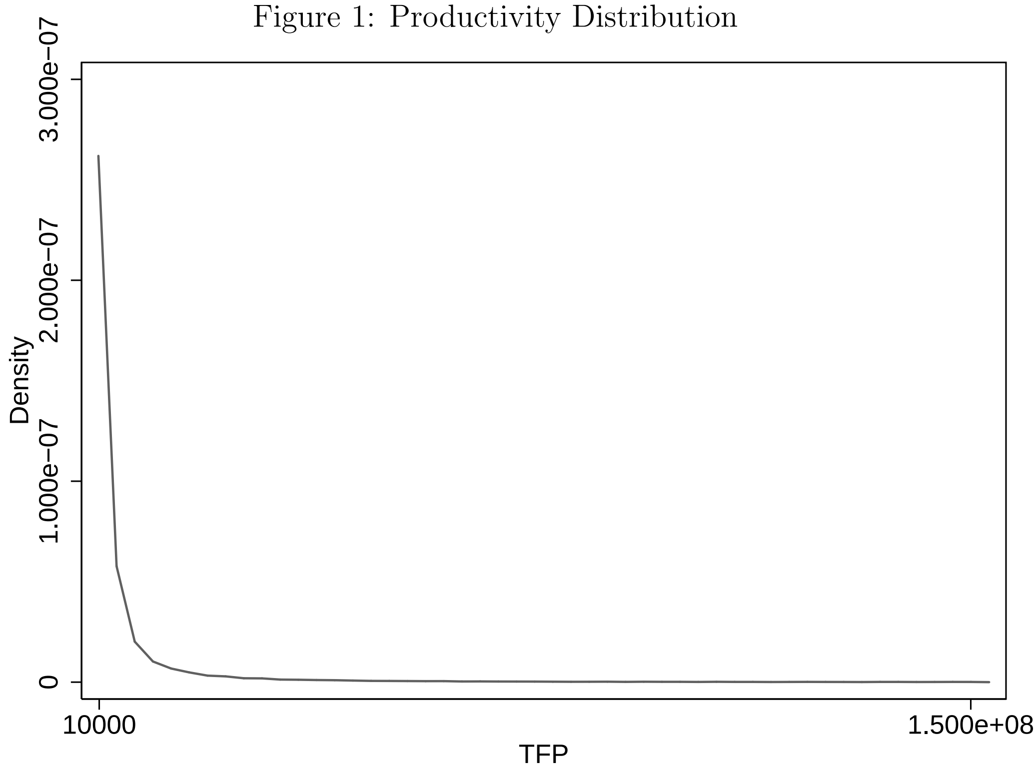
3.2 Empirical Model

To quantify the sectoral EP, we estimate variants of the following baseline specification:

$$\begin{aligned} \ln Y_{it} &= \alpha_i + \beta_{ck} Cap_{it} + \beta_{lk} Lab_{it} \\ &+ \delta Exp_{it} + \eta V_{jt} + \theta (Exp_{it} V_{jt}) + Year_t + \epsilon_{it}, \end{aligned} \tag{9}$$

[9] Part-time workers receive a weight of 0.5.

Figure 1: Productivity Distribution



with Y_{it} representing value added of firm i at time t. Cap and Lab denote the input factors capital and labor for which we estimate separate elasticities β_{ck} and β_{lk} at the two-digit industry level k.[10] Exporter status is represented by the dummy variable Exp while V_{jt} represents industry j specific characteristics as outlined in Section 2, such as the degree of heterogeneity in productivity among the firms in the industry measured at the 3-digit level with $i \in j$. Firm-specific unobserved characteristics are captured by α_i and are assumed to be constant over time. Including firm fixed effects in our main specification implies that the exporter productivity premium

[10] Accordingly, our model is equivalent to a standard TFP regression that obtains log TFP from a first-stage production function estimation at the two-digit industry level. As many studies rely on simple labor productivity measures we also, for completeness, evaluate the labor productivity premium of export status estimating the following model:

$$\ln\left(\frac{Y_{it}}{Lab_{it}}\right) = \alpha_i + \delta Exp_{it} + \eta V_{jt} + \theta(Exp_{it}V_{jt}) + Year_t + \epsilon_{it}.$$

is identified through within-firm variation in export status combined with cross-section and time variation in industry characteristics reflected in the interaction term.

Moreover, in order to test for the robustness of our findings we proceed by estimating a Levinsohn-Petrin specification of the above model allowing for time-changing firm-specific shocks α_{it} (see Levinsohn and Petrin, 2003).[11]

Finally, $Year_t$ denotes a full set of time dummies capturing common time specific shocks. The remaining error term ϵ_{it} is allowed to be heteroscedastic and contemporaneously correlated within industries.[12] As firms do not switch between industries in our data, we do not include industry fixed effects.

To further test for the robustness of our findings, we also estimate a difference-in-difference specification of (9) that allows for firm-specific productivity trends that may determine selection into exporter status. Accordingly, in this specification we compare exporting firms to non-exporting firms that before their actual export spells were on the same productivity trajectory:

$$\begin{aligned} \triangle \ln Y_{it} &= \alpha_i + \beta_{ck} \triangle Cap_{it} + \beta_{lk} \triangle Lab_{it} \\ &+ \delta \triangle Exp_{it} + \eta \triangle V_{jt} + \theta \triangle (Exp_{it} V_{jt}) + \triangle Year_t + \triangle \epsilon_{it}. \end{aligned} \tag{10}$$

In order to rule out that our findings are driven by the previously discussed potential reversed causality, i.e. by learning through exporting instead of self-selection, we also estimate a variant of (9) using $\ln Y_{it-3}$ as the dependent variable.

According to the above models, the exporter productivity premium expressed in percent is:

$$PR_j = \left(e^{\delta + \theta V_{jt}} - 1\right) * 100. \tag{11}$$

Hence, we allow the exporter productivity premium to vary according to industry characteristics V as predicted by theory. Obviously, our estimations serve to reflect upon the theory, and remain descriptive in nature since, in order to avoid multicolinearity, we do not control simultaneously for all considered industry characteristics. In order to test Corollaries 1 to 5, we subsequently assess a number of sector characteristics.

First, the degree of heterogeneity in the productivity distribution is measured by the industries standard deviation of log labor productivity. Note that in our theoretical model this measure reads

$$Std\left(\log \varphi_j\left(\omega\right) \middle| \varphi_j\left(\omega\right) \geq \varphi_{j,d}^*\right) = \gamma_j^{-1}\ .$$

[11] We opt for the Levinsohn-Petrin specification as opposed to the method introduced by Olley and Pakes (1996) to avoid selection bias on the basis of missing investments.

[12] We allow for contemporaneous correlation at the 2-digit level nesting 3-digit industries.

Accordingly, the relation between the empirical exporter productivity premia and productivity dispersion is directly comparable to Corollary 1, cf. (8) and we expect sectors with a higher degree of heterogeneity in productivity to command larger EPs.

Next, we move to Corollaries 2 to 5. However, in contrast to our measure of γ_j, there are no straightforward and directly observable empirical measures corresponding to $f_{j,x}, \tau_j, f_j$ and σ_j. Accordingly, we have to relay on a number of proxies.

We propose to capture sectoral fixed export costs, $f_{j,x}$, by (i) the per sector average of firms foreign sales volume – indicating minimum efficiency scale of the export activity – and (ii) the sector average of number of destinations served per firm – with more destinations implying larger initial (destination-unspecific) fixed export costs. We expect to find a positive relation to the sectoral EP (Corollary 2).

We proxi variable iceberg trade costs, τ_j, by (i) the share of foreign sales in total sales of exporters in an industry (whereby, in theory, a larger share stems from lower variable trade costs) and (ii) alternatively by an inverse trade costs measure, derived as the industry export weighted distance of export destinations (whereby we argue that sectors serving more distant markets have lower variable trade costs). Obviously both measures are heavily affected by market size and demand-side asymmetries and will thus only imperfectly capture variable trade costs. According to Corollary 3 higher variable trade costs should result in larger EP.

We attempt to represent fixed costs of production by the sectoral average of firms' domestic sales; such that larger scale would indicate larger fixed costs. In terms of a theoretical prediction we expect that higher fixed costs of production are associated with a lower sectoral EP (Corollary 4).

Finally, we attempt to provide some first insight into the role of product differentiation for the magnitude of the EP (Corollary 5), by measuring (i) average firm product variety, i.e. the total number of differentiable exported goods (applying the Combined Nomenclature at the 8-digit level) in an industry and by measuring (ii) the share of homogenous goods, as classified by Rauch (1999), in total exports of an industry.

4 Results

Table 1 presents the estimated EPs applying the different previously outlined estimation techniques. According to equation (11) the EP is allowed to differ along 3-digit industry characteristics V. For this reason we present EPs calculated at the mean, the bottom decile, the median, and the top decile of the respective industry measure V.[13]

First, focussing on the estimates regarding industry-level productivity heterogeneity reported in Panel (1) of Table 1 we find the same pattern as predicted by Corollary 1. For instance, applying our baseline TFP model (9) we find that in industries which are most homogenous in terms of productivity exporting firms experience a productivity premium of 16 percent. In contrast, in the industries with the highest productivity heterogeneity exporter status yields productivity premia of 34 percent. Importantly, this pattern is robust to the used estimation technique. Irrespective of whether we base our estimates on simple labor productivity measures, a Levinsohn-Petrin model specification accounting for firm- and time-specific shocks, or the difference-in-difference model from equation (10), EPs monotonously increase with industry-level productivity heterogeneity.

Second, in line with Corollary 2 we find EPs to monotonously increases with fixed export costs captured by the industry-specific average size of foreign sales and the average number of export destinations. As reported in panel (2) of Table 1, when focusing on the TFP estimates, the average EP differential between firms in industries with the highest and industries with the lowest fixed costs of exporting is more than 15 percentage points. Again, the identified pattern is robust to the estimation technique.

Third, when considering variable trade costs, we find some evidence that EPs are the higher the smaller variable trade costs are. As becomes apparent in Panel (3) of Table 1, the pattern is, however, only weakly pronounced with EP differences between the top and bottom deciles of our iceberg trade costs proxies not being statistically significant. Furthermore, the identified pattern is not entirely robust to the chosen estimation technique. Accordingly, our empirical evidence presented here on Corollary 3 is inconclusive.

Fourth, when analyzing the proxy for fixed costs of production, we find the pattern of lower EP for larger fixed costs predicted by Corollary 4 only in the Levisohn-Petrin specification, see Panel (4) of Table 1. For the other three specifications the reverse pattern is established. For example, for our TFP estimates exporting firms belonging to industries within the bottom decile of fixed costs on average have an EP of 20 percent while firms belonging to industries in the top decile of fixed production costs experience an average EP of around 33 percent.

Fifth, regarding our estimates on product differentiation results are re-

[13]Note that the available number of observations varies with the different estimation techniques. Furthermore, due to item non-response with respect to V, the models vary slightly with respect to the number of observations. As the focus of this exercise is on the patterns outlined in Corollaries 1 to 5, we do not restrict the sample to be common across all analyzed dimensions of V.

ported in Panel (5) of Table 1. While Corollary 5 had no clear result on the role of product differentiation, our empirical analysis finds EPs to monotonously increase with product variety irrespective of the used estimation technique. Based on the TFP model, EPs range between 13 and 34 percent for the bottom and top decile of product variety. When capturing product differentiation by the share of homogenous goods applying the classification scheme of Rauch (1999), we find similar effects that are, however, much less pronounced. Again relying on the TFP model, average EPs are smallest for firms in industries that belong to the top decile with respect to the share of homogenous goods and largest for firms belonging to industries having the smallest share of homogenous goods. However, differences in EPs are statistically not significant between the top and bottom deciles which may be attributable to the somewhat arbitrary classification scheme for homogenous goods.

Finally, we test whether our EP estimates are robust to potential reversed causality, i.e. to the idea that the most productive firms do not select into exporting but become more productive through exporting. To do so we estimate Equation 9 with Y_{it-3} as the dependent variable, hence, we quantify EPs prior to exporting thereby reducing potential simultaneity. The respective EP estimates are presented in Table 2. Most notably, although EPs are overall smaller than in our previous regressions, we find the same patterns as before.

5 Conclusion

Exporter productivity premia are a central stylized fact of international commerce, albeit the accumulated empirical evidence discloses substantial – and so far unexplained – EP size differences between countries and across sectors within countries. The present paper tackles this issue both theoretically and empirically. First, we ask if at all – and in what direction – the existing new workhorse model of heterogeneous firms trade (e.g. Melitz, 2003) contains predictions on the determinants of magnitude for exporter productivity premia. In particular, we include the theoretical equivalent of the empirical EP measure into a version of the Melitz (2003) model. Second, we compare the theoretical predications to the evidence derived from Danish firm-level data, by estimating a range of empirical models commonly found in the literature. We are able to identify an important role for fixed trade costs and for the degree of heterogeneity in productivity in explaining the variance in EP magnitude. Both theoretically and empirically, industries where the realized productivity distribution displays a wider variance feature larger EPs; similarly, industries with higher fixed trade costs display larger EPs. Moreover, we show that while in theory the degree of product differentiation gives ambiguous results, empirical evidence suggests that EPs are larger in industries with more differentiated products.

Setting our findings in perspective to the sizable empirical literature on exporter productivity premia, we see two directions in which the present paper contributes. Firstly, we document that the size of estimated EPs varies systematically with the chosen estimation methods. By presenting not only the customary labor productivity and TFP estimates, but also Diff-in-Diff and Levinsohn-Petrin specifications, we show that the largest EPs result from estimating the TFP based model. These EPs, however, shrink radically when implementing a Levinsohn-Petrin specification. The smallest EP estimates result from our Diff-in-Diff specification. Secondly, despite this influence on measured EP magnitude stemming from estimation methods, we are able to identify some central fundamentals that matter – and are robust to the various specifications tested. We establish that the variance in the underlying productivity distribution, the size of sectoral fixed export costs, and the degree of product differentiation are decisive fundamentals for EP realizations. These findings will help to refine future empirical research into exporter performance and help to explain the wide range of EPs across different countries and industries.

References

Aw, B.Y., S. Chung, and M.J. Roberts (2000) 'Productivity and Turnover in the Export Market: Micro-level Evidence from the Republic of Korea and Taiwan (China),' *The World Bank Economic Review* 14, 65-90.

Aw, B. Y., and A. R. Hwang (1995) 'Productivity and the Export Market: A Firm-level Analysis,' *Journal of Development Economics* 47, 313332.

Axtell, R.L. (2001) 'Zipf Distribution of U. S. Firm Sizes, ' *Science* 293(5536), 1818-1820.

Bernard, A.B., J. B.Jensen, S.J. Redding, and P.K. Schott (2007) 'Firms in International Trade,' *Journal of Economic Perspectives* 21 (3), 105-130.

Bernard, A.B., J.B. Jensen, S.J. Redding and P.K. Schott (2012) 'The Empirics of Firm Heterogeneity and International Trade,' *Annual Review of Economics*, forthcoming.

Bernard, A.B., J. Eaton, J.B. Jensen, and S. Kortum (2003) 'Plants and Productivity in International Trade,' *American Economic Review* 93, 1268-1290.

Chaney, T. (2008) 'Distorted Gravity: Heterogeneous Firms, Market Structure, and the Geography of International Trade,' *American Economic Review* 98, 1707-1721.

Dixit, A.K., J.E. Stiglitz (1977) 'Monopolistic Competition and Optimum Product Diversity, ' *American Economic Review* 67(3), 297-308.

Eaton, J., S.S. Kortum and S. Sotelo (2012) 'International Trade: Linking Micro and Macro,' NBER Working Paper 17864.

Farinas, J. C., and A. Martin-Marcos (2007) 'Exporting and Economic Performance: Firm-level Evidence of Spanish Manufacturing,' *World Economy* 30, 618-646.

Greenaway, D., and R. Kneller (2007) 'Firm Heterogeneity, Exporting and Foreign Direct Investment,' *The Economic Journal* 117, 134-161.

Head, K., and J. Ries, (2003) 'Heterogeneity and the foreign direct investment versus exporter decision of Japanese manufacturers,' *Journal of the Japanese and International Economics* 17, 448-467.

Helpman, E., M.J. Melitz, and S.R. Yeaple (2004) 'Export versus FDI with Heterogeneous Firms,' *American Economic Review* 94, 300-316.

ISGEP – International Study Group on Exports and Productivity (2008) 'Understanding cross-country differences in export premia: Comparable evidence for 14 countries, *Review of World Economics* 144, 596-635.

Kneller, R., and M. Pisu (2010) 'The returns to exporting: evidence from UK Firms,' *Canadian Journal of Economics* 43 (2), 494-519.

Levinsohn, J., and A. Petrin J. Levinsohn (2003) 'Estimating Production Functions Using Inputs to Control for Unobservables,' *Review of Economic Studies* 70, 317-341.

López, R.A. (2009) 'Do Firms Increase Productivity in Order to Become Exporters?,' *Oxford Bulletin of Economics and Statistics* 71 (5), 621-642.

Luttmer, E.G. (2007). Selection, Growth , and the size distribution of firms. *Quarterly Journal of Economics*, Vol. 122(3), pp. 1103-1144.

Mayer T., and G.I.P. Ottaviano (2007) *The Happy Few: The internationalisation of European firms - New facts based on firm-level evidence*, Bruegel Blueprint Series, Vol. III, Bruegel, Brussels

Melitz, M.J. (2003) 'The Impact of Trade on Intra-industry Reallocations and Aggregate Industry Productivity,' *Econometrica* 71, 1695-1725.

Meller, P. (1995) 'Chilean Export Growth, 1970-90: An Assessment,' in: *Manufacturing for Export in the Developing World : Problems and Possibilities*, Helleiner, Gerald K. (ed), Routledge.

Merino, F. (2004) 'Firms' productivity and internationalization: a statistical dominance test,' *Applied Economics Letters* 11, 851-854.

Olley, S., and A. Pakes (1996) 'The dynamics of productivity in the telecommunications equipment industry,' *Econometrica* 64 (6), 1263-1298.

Rauch, J. E. (1999) 'Networks versus markets in international trade,' *Journal of International Economics*, 48(1), 7-35.

Redding, S. J. (2011) 'Theories of Heterogeneous Firms and Trade,' *Annual Review of Economics* 3, 77-105.

Schröder, P.J.H., and A. Sørensen (2012) 'Second Thoughts on the Exporter Productivity Premium,' *Canadian Journal of Economics*, forthcoming.

Simon, H.A., and C.P. Bonini (1958) 'The Size Distribution of Business Firms,' *American Economic Review* 48(4), 607-617.

Vinzenzo, V., and J. Wagner (2011) 'Robust Estimation of Linear Fixed Effects Panel Data Models with an Application to the Exporter Productivity Premium,' *Jahrbücher f. Nationalökonomie u. Statistik*, 231 (4), 546-557.

Wagner, J. (2007) 'Exports and Productivity: A Survey of the Evidence from Firm-level Data,' *The World Economy* 30, 60-82.

Wagner, J. (2012) 'International Trade and Firm Performance: A survey of empirical Studies since 2006,' *Review of World Economics*, forthcoming.

Table 1: **Exporter Productivity Premium in percent**

	Mean V	Bottom Decile V	Median V	Top Decile V	Obs.	Firms
Corollary 1						
V ≡ Productivity Heterogeneity						
Labor Prod.	15.61***	8.51***	14.03***	24.58***	255290	41326
	(1.45)	(2.03)	(1.52)	(2.06)		
TFP	24.14***	16.41***	22.42***	33.92***	255290	41326
	(1.66)	(2.74)	(1.81)	(2.52)		
TFP, Diff-in-Diff	7.13***	2.41	6.09***	12.96***	209553	34503
	(0.77)	(1.84)	(0.94)	(1.70)		
Levinsohn-Petrin	16.69***	14.20***	16.17***	19.68***	163208	24569
	(1.41)	(2.30)	(1.56)	(1.38)		
Corollary 2	Mean V	Bottom Decile V	Median V	Top Decile V	Obs.	Firms
i: V ≡Average size of foreign sales						
Labor Prod.	15.63***	9.55***	16.23***	21.09***	255207	41323
	(1.57)	(3.66)	(1.52)	(2.80)		
TFP	24.99***	16.79***	25.56***	32.18***	255207	41323
	(1.24)	(2.60)	(1.27)	(2.71)		
TFP,Diff-in-Diff	7.49***	4.44***	7.69***	10.06***	209463	34497
	(0.55)	(0.97)	(0.57)	(1.11)		
Levinsohn-Petrin	16.82***	13.73***	17.16***	19.47***	163181	24569
	(1.24)	(4.57)	(1.06)	(2.81)		
ii: V ≡ Average number of export destinations						
Labor Prod.	15.69***	9.25***	16.43***	21.74**	255162	41322
	(1.48)	(2.99)	(1.45)	(2.53)		
TFP	23.90***	13.08***	25.16***	34.39***	255162	41322
	(1.34)	(1.70)	(1.40)	(2.34)		
TFP,Diff-in-Diff	7.28***	5.53***	7.47***	8.85***	209412	34496
	(0.51)	(0.88)	(0.52)	(0.85)		
Levinsohn-Petrin	16.91***	13.49***	17.24***	19.77***	163157	24568
	(1.25)	(3.59)	(1.11)	(1.86)		

Notes: *, **, *** Statistically significant at the 10 percent, the 5 percent, the 1 percent level, respectively.

Table 1: **...continued**

	Mean V	Bottom Decile V	Median V	Top Decile V	Obs.	Firms
	Corollary 3					
	i: V ≡ Share of foreign sales of exporters					
Labor prod.	16.25	15.42***	16.25***	16.98***	255169	41322
	(1.45	(1.81	(1.45	(1.82		
TFP	24.76***	22.73***	24.76***	26.53***	255169	41322
	(1.72)	(2.17)	(1.72)	(1.82)		
TFP,Diff-in-Diff	7.26***	6.83***	7.26***	7.64***	209418	34497
	(0.55)	(0.63)	(0.55)	(0.90)		
Levinsohn-Petrin	16.94***	15.46***	16.98***	18.23***	163167	24568
	(1.25)	(2.09)	(1.24)	(1.07)		
	ii: V≡Average export weighted distance					
Labor Prod.	16.07***	13.87***	16.08***	18.51***	255162	41322
	(1.46)	(2.27)	(1.45)	(1.95)		
TFP	24.67***	22.77***	24.68***	26.78***	255162	41322
	(1.90)	(2.90)	(1.90)	(1.76)		
TFP,Diff-in-Diff	7.28***	7.23***	7.28***	7.34***	209412	34496
	(0.65)	(1.29)	(0.65)	(0.82)		
Levinsohn-Petrin	16.96***	17.48***	16.95***	16.34***	163157	24568
	(1.51)	(2.46)	(1.49)	(1.36)		

Notes: *, **, *** Statistically significant at the 10 percent, the 5 percent, the 1 percent level, respectively.

Table 1: **...continued**

	Mean V	Bottom Decile V	Median V	Top Decile V	Obs.	Firms
Corollary 4						
		V≡Average size of domestic sales				
Labor Prod.	15.94***	13.16***	15.88***	18.49***	255290	41326
	(1.65)	(2.98)	(1.66)	(1.93)		
TFP	26.73***	19.94***	27.19***	32.61***	255290	41326
	(1.95)	(2.39)	(2.02)	(3.29)		
TFP,Diff-in-Diff	7.66***	6.42***	7.75***	8.70***	209553	34503
	(0.87)	(0.58)	(0.92)	(1.64)		
Levinsohn-Petrin	17.07***	19.08***	17.14***	15.27***	163215	24569
	(1.54)	(2.22)	(1.55)	(1.63)		

	Mean V	Bottom Decile V	Median V	Top Decile V	Obs.	Firms
Corollary 5						
		i: V ≡ Product Variety				
Labor Prod.	15.72***	6.58***	15.90***	25.39***	255290	41326
	(1.23)	(2.19)	(1.24)	(3.01)		
TFP	23.90***	13.08***	25.16***	34.39***	255290	41326
	(1.34)	(1.70)	(1.40)	(2.34)		
TFP,Diff-in-Diff	7.28***	5.53***	7.47***	8.85***	209553	34503
	(0.51)	(0.88)	(0.52)	(0.85)		
Levinsohn-Petrin	16.93***	16.49***	16.95***	17.35***	163215	24569
	(1.35)	(3.98)	(1.28)	(2.53)		
		ii: V ≡ Share of homogenous goods				
Labor Prod.	16.59***	17.12***	17.10***	15.42***	195494	37006
	(1.69)	(1.76)	(1.76)	(1.68)		
TFP	25.79***	26.30***	26.29***	24.65***	195494	37006
	(2.20)	(2.37)	(2.36)	(1.86)		
TFP, Diff-in-Diff	7.79***	8.03***	8.02***	7.26***	146038	26119
	(0.54)	(0.55)	(0.55)	(0.58)		
Levinsohn-Petrin	17.20***	17.82***	17.80***	15.88***	127684	22554
	(1.10)	(1.14)	(1.14)	(1.03)		

Notes: *,**,*** Statistically significant at the 10 percent, the 5 percent, the 1 percent level, respectively.

Table 2: **Exporter Productivity Premium in percent, TFP model with** $\ln Y_{it-3}$

Mean V	Bottom Decile V	Median V	Top Decile V	Obs.	Firms
Corollary 1					
V ≡ Productivity Heterogeneity					
5.75***	4.56***	5.45***	7.39***	147569	26275
(0.74)	(0.91)	(0.76)	(0.95)		
Corollary 2					
i:V≡Average size of foreigns ales					
5.45***	2.37	5.75***	8.16***	147555	26275
(0.73)	(1.40)	(0.73)	(1.17)		
ii:V≡Average number of export destinations					
5.54***	2.76*	5.85***	8.07***	147516	26274
(0.81)	(1.42)	(0.81)	1.29		
Corollary 3					
i:V≡Share of foreign sales of exporters					
5.78***	4.38***	5.77***	7.09***	147519	26274
(0.75)	(1.14)	(0.75)	(0.84)		
ii:V≡Average export weighted distance					
5.76***	5.04***	5.78***	6.64***	147516	26274
(0.84)	(1.38)	(0.83)	(1.13)		
Corollary 4					
V≡Average size of domestic sales					
5.53***	3.92**	5.50***	7.01***	147569	26275
(0.79)	(1.64)	(0.80)	(1.16)		
Corollary 5					
i:V≡Product Variety					
5.28***	2.12*	5.13***	8.96***	147569	26275
(0.80)	(1.16)	(0.80)	(1.22)		
ii:V≡Share of homogenous goods					
6.47***	6.44***	6.45***	6.51***	113970	23516
(1.15)	(1.30)	(1.29)	(0.93)		

Notes:*,**,***Statistically significant at the 10 percent, the 5 percent,the 1 percent level, respectively.